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It will be seen from these tables that my altitudes were in general a little too high. To produce this the difference in the state of the atmosphere at the meteorological station near the sea-coast, and at the same time on or near the summit of the passes in the interior, may have had some influence on the readings of my instruments, not to speak of minor index errors.

The table shows thus once more convincingly that although mathematical correctness cannot be claimed for altitudes calculated from barometric observations, they are nevertheless sufficiently accurate for all practical purposes. And every observer must rejoice that even single observations, when carefully taken, possess more intrinsic value than is generally allowed to them.

I am afraid that these few observations will not be of sufficient interest to warrant my laying them before the Society, which receives such valuable and instructive papers from all parts of the world; but my desire to make geographers acquainted with some of the results obtained lately by me when enquiring into the physical geography of some portion of this beautiful island will, I trust, be sufficient excuse for my having done so.

Christchurch, December 27, 1866.

XVII.—*On the Subterranean Supply of Water in Beloochistan and the Hill Districts of Western Sind.* By J. W. BARNS, Esq., C.E., F.R.G.S., late of H.M. Bombay Public Works Department.

HAVING resided the greater portion of the period since 1845 in Sind, where, from the scarcity of rain, water, and above all running water, is the "summum bonum" of the land, and where its economical application to irrigational purposes formed the nature of my duties on the Staff of Colonel (then Captain) Fife, our great hydraulic engineer, I had long entertained the idea that subterranean water existed in certain localities in the hills, capable of overflowing through artesian borings if they were made, and in 1865-6 I determined, after a critical examination of the hills bordering Sind, to give this mode of obtaining water a trial.

The place selected for my labours was distant about 8 miles north-east of Kurrachee, and I had the satisfaction after some weeks' labour of piercing the first water-bearing stratum, when the water rushed up and overflowed the surface, continuing, without intermission, to flow to this day.

The water is of a temperature of 85°, and as the stratum in which it is found is a saline aluminous shale, it is, from percolation through the same, slightly brackish, but at the same time useful for irrigation; and although not such as would be preferred for household purposes, myself and the men engaged on this work used no other for twelve months.

Most of the large springs in the hills proceed from the nummulitic formation which forms the back-bone of the Hala range, and are brackish. Springs frequently occur in the selfsame locality as the more deep-seated springs from the nummulitic, but in a much more recent formation. I apprehend that whereever the superior aluminous shales yield, as in the case of my borings, a continuous flow of water, we may reasonably calculate on a larger and purer yield if the borings are continued to the lower tertiary strata.

Although I have succeeded, as mentioned, in getting a continuous flow of water, and that at a high level, it must not be inferred that this is the only proof of its existence. Within 4 miles of these borings on either side are natural springs, viz., two on the north-west at Muggur Pur, aggregating a discharge of 180,000 gallons in the twenty-four hours, with a temperature of 126° and 98° respectively, and another south-west at Wapda discharging one-fifth of that quantity.

In another part of the hills within 40 miles of Kurrachee there are tracts of many square miles in extent covered with travertine, containing recent fresh-water shells, and from 10 to 12 inches in thickness; thus showing indisputably the flow of spring-water charged with bicarbonate of lime for a very long period. At Pur Ghazee, near Schwan, is a remarkable spring, discharging one and a half million gallons per day, over a precipice 270 feet high. Indeed the whole of this portion of the hills, for a breadth of 100 miles from Kurrachee to Khelat and the Boolan Pass,* contains such a vast number of springs and small streams that it is impossible to detail them. Many of these are used up in irrigation, and a still greater number, after flowing from one to ten miles, disappear in the sand, or flow off into cavities of the limestone formation, through which they pass, to appear again, doubtless, in places at a lower level, where faults bring the water to the surface.

In proof that these springs, and consequently the subterranean water generally, derive their head of water, and therefore their first source, from some spot far removed from their immediate locality, I should mention that most of them at their point of issue over the surface of the ground are from 60 to 300 feet above the valleys in their own immediate parallel. Thus, for instance, the spring at Muggur Pur † flows to an elevation of

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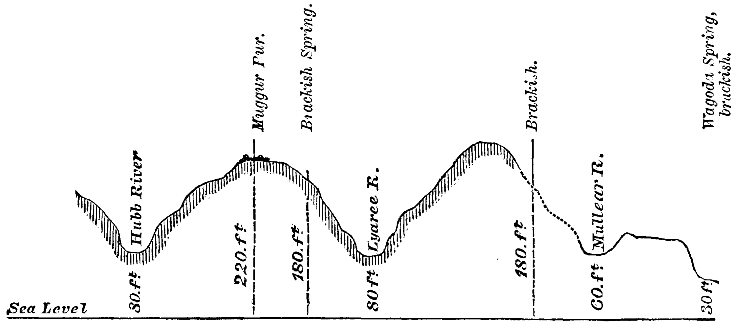
* Vide Masson's 'Tour in Affghanistan.'

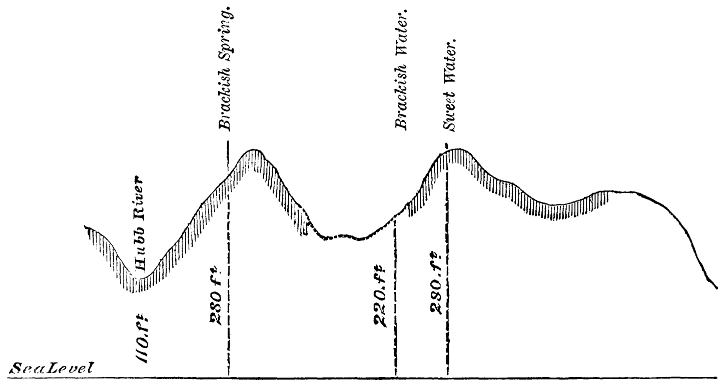
† Nine miles from Kurrachee.

220 feet above sea-level, whereas the water, in the two valleys between which the hill giving rise to this spring is situated, is not more than 80 feet. Again, at a section across the country east and west, 25 miles north of Kurrachee, the subterranean water issues at 280 feet above sea-level, whilst the Hubb River in the adjoining valley stands at 110 feet.

Section at Muggur Pur.



Section 25 miles north of Kurrachee.



Many other sections would give somewhat similar results.

With this evidence of the presence of subterranean water we are bound not to stop in our inquiries, and hence arises the question, where is the source?

In dealing with this question we start with the absolute certainty that wherever water is found inland, whether in the shape of springs or rivulets, it has but one origin, namely, the supply from the clouds in the form of rain and snow.

We are in the habit, because some large portion of these zones just beyond the Tropics contains vast deserts, and has no rivers draining towards the ocean, that there is literally no rainfall; but it is a mistake; even Sind, which is spoken of often as being destitute of rain, gauged a rainfall of 40 inches in some parts within three months last summer, and averages I believe four inches per annum. But if we glance at a map of Asia, we observe between the eastern borders of Persia and the western boundary of the Sind and Punjaub valleys a tract of country 330,000 square miles in extent, with an enormous area of mountain land from 3000 to 12,000 feet above sea-level, and, as Pottinger remarks, "subject to heavy falls of snow; showery in the months of September and October, and the whole of the cold season (viz., from November to March inclusive), more or less so; so that four or five days seldom pass without either sleet or rain. Even Mekran and Lus," he goes on to state, "have their wet season in February and March, and also June, July, and part of August."

I have no doubt that these remarks refer especially to the mountainous tracts of Affghanistan and Beloochistan, and not to the desert portions of Seistan to the west and south-west.

I have not obtained access to any meteorological registers of this region, and therefore endeavour to arrive at an approximation of the average rainfall by other means. For the purposes of this paper I think I can show sufficient *à priori* evidence of considerable rainfall in the mountainous parts of these countries, and that consequently there must, as is the case in every country in the world under similar circumstances, be a considerable subterraneous supply available in that tract lying to the southward of the 30th degree of latitude.

As regards the subterranean supply in the hills from Kurrachee north to Khelat, I am of opinion that, if no other accessory were available, the proximity of Khelat to Kurrachee, viz., 200 miles, its position with regard to the slope of the country, which is north and south, and its being the southern terminus of an elevated range of mountains, from 6000 to 12,000 feet above sea-level, culminating in the great lateral range of the Hindoo Kush, running east and west (portions of which are covered with perpetual snow), I am of opinion that this range alone, on the elevated parts of which snow lies for many parts of the year, must be an enormous source of subterranean water.

Turning to the map, we observe all the rainfall of the region comprised within a line from Khelat through Ghuznee on the east, the 30th degree of latitude on the south, the 34th degree of latitude on the north, and the longitude of 62° on the west, culminating to one point, viz., the Lake Hamoon, or, as it is known to geographers, the "Aria Palus," a hydrographical basin equal in extent to that of the great River Euphrates, viz., 108,000 geographical miles, like those of the Helmund and its tributaries, are lost in a sea of marshes.

Most travellers agree in assigning the dimensions of this lake during the period of the melting of the snows to be 70 miles long by 15 to 20 miles in breadth; or, in round numbers, say 1000 square miles, whilst Pottinger leads us to understand that its ordinary dimensions are 30 by 12, or say 350 square miles. This, I believe, will, until it shall have been further investigated, enable us to roughly estimate by analogy the average rainfall of this watershed.

In Sind, viz., the interior, I have found ponds to lose one inch in depth per diem from August to January, and lakes in the Thurr Desert to lose half an inch per diem until they decrease so much in depth as to receive their equivalent in evaporation from springs.

In Calcutta (a humid climate) 15 feet per annum is the amount proved by registry, being nearly half an inch per diem; whilst at Greenwich 5 feet is allowed; in Bombay ·26 of an inch is the amount of daily evaporation during the dry months; and although it is generally supposed that evaporation is considerably less over large areas than small ones, still these registries refer to evaporation pure and simple, and do not include the portion due to percolation. This lake is described as being nowhere more than 3 to 4 feet in depth, and covered with reeds. Captain Conolly says that for four months in the year, during the summer solstice, evaporation must be excessive, from the absorption by the scorching rays prevalent in that season; indeed when, as Major Rawlinson informs us, the summer heat in a bungalow is 120°, and the temperature of running water at Bushire 90°, we must assume for evaporation, vegetation, and percolation, during the four summer months, when we know no dew can possibly fall, at least one inch per diem, and for the other eight months let us assume the loss from those causes not to exceed a quarter of an inch per diem; it will then be found that, although this allows for a discharge from all the rivers combined of 1,613,333 * cubic feet per minute during the four months when snow is melting, and 141,166 † cubic feet per minute during the other eight months (the discharge of the Euphrates being estimated at 14,214,466 cubic feet, or nearly nine times the estimated discharge of the Helmund and the other rivers flowing into Lake Hamoon) it only represents 1·31 inch, or a little over an average of one inch of rainfall per annum.

Now we have a perfect right to assume that this quantity of 1·31

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* Equal to 40 such rivers as the Thames, at Staines, in the summer flow.

† Equal to 3½ such rivers as the Thames in summer flow.

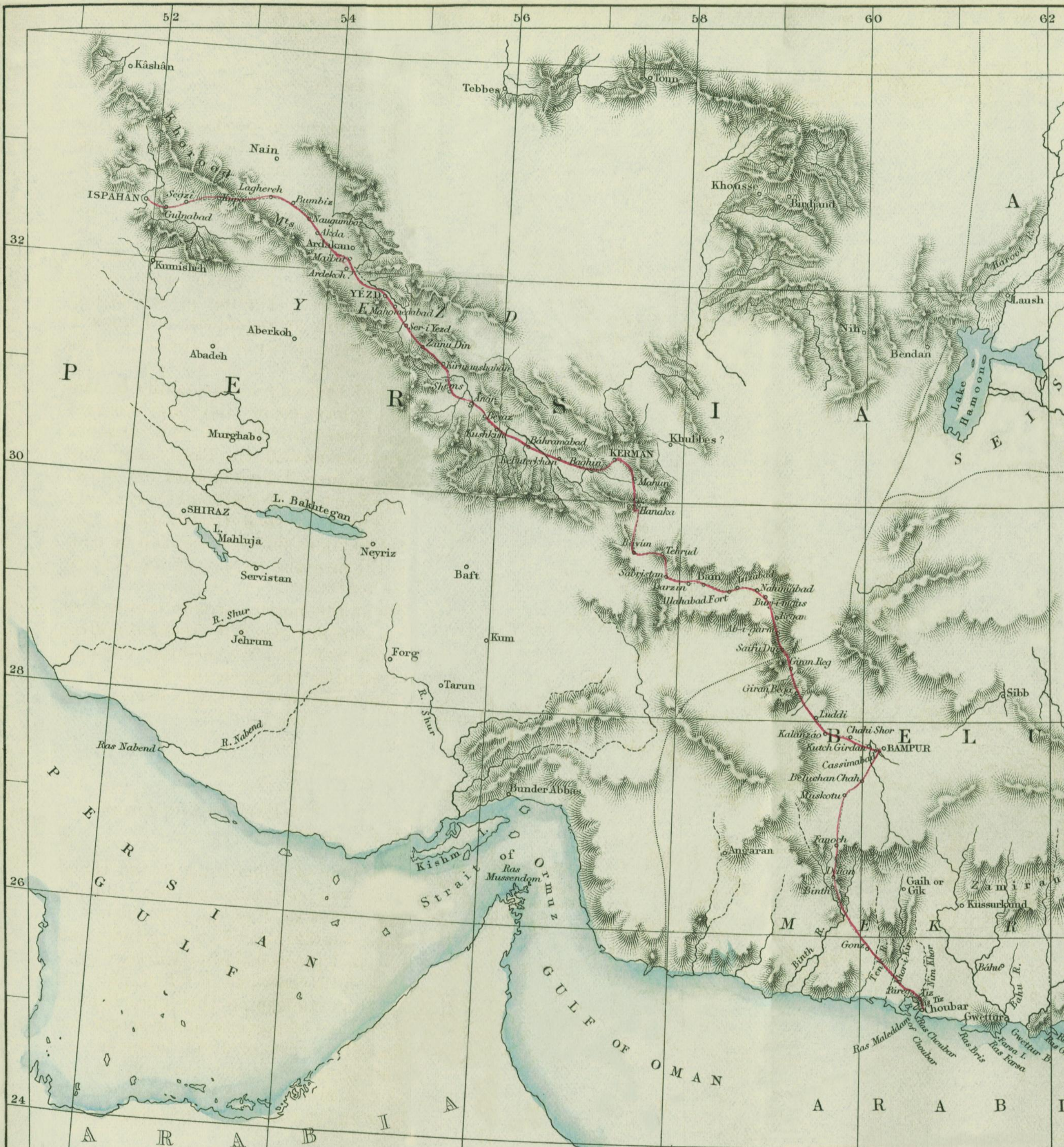
inch per annum is at least only one-third of the average rainfall, which would give us a total average rainfall of 4 inches per annum over the area of this geographical basin; and as we know that in every country in the world a portion of the rainfall (estimated variously from one-third to one-twelfth) percolates and is absorbed by the soil and the permeable strata, and that the whole of this basin is elevated much above the sea-level, and that according to tradition the Helmund formerly discharged itself into the Indian Ocean, there is room for a strong inference in my opinion that a vast body of water is available, in the whole of that region between the 30th parallel of latitude and the sea. It is recorded by navigators that large springs of fresh water burst up through the sea in the neighbourhood of Cape Ormuz; the same thing has been observed off Cape Monge; and I doubt not if attention were called thereto the same phenomenon would be observed in other parts of the coast. The formation of this part is undoubtedly tertiary, and the stratification of the hills where not horizontal generally inclines either to the eastward or southward. It will be recollected that under somewhat similar conditions the French engineers a few years since have brought a perennial flow of water in many parts of the Algerian Desert.

I regret that I have felt it necessary, in order to attempt to convey my ideas and information on this very interesting subject, to have been led into such a lengthy paper, and should it have no better effect than to excite inquiry and attention to this subject, I shall consider the labour I have bestowed amply repaid.

XVIII.—*Notes on the Pangong Lake District of Ladakh, from a Journal made during a Survey in* 1863. By Capt. H. H. Godwin-Austen, F.R.G.S., Topographical Survey.

Read, December 10, 1866.

To the north of the Indus, from its junction with the Dras River, lies a high range of mountains which separate the Indus drainage from that of the Shayok or Nùbra River. The axis and great mass of this range is granitic; on the west this extends to within a very short distance of the river, while at Pitùk below Leh, the granitic hill on which that large and well-known monastery stands abuts on the Indus itself, and thence towards the east for a considerable distance it holds the same position. The great mass of coarse sand-stones, red clays, grits, and conglomerates, seen on the right bank of the Indus, west of Pitùk, are now seen on the left or south bank, thence to the



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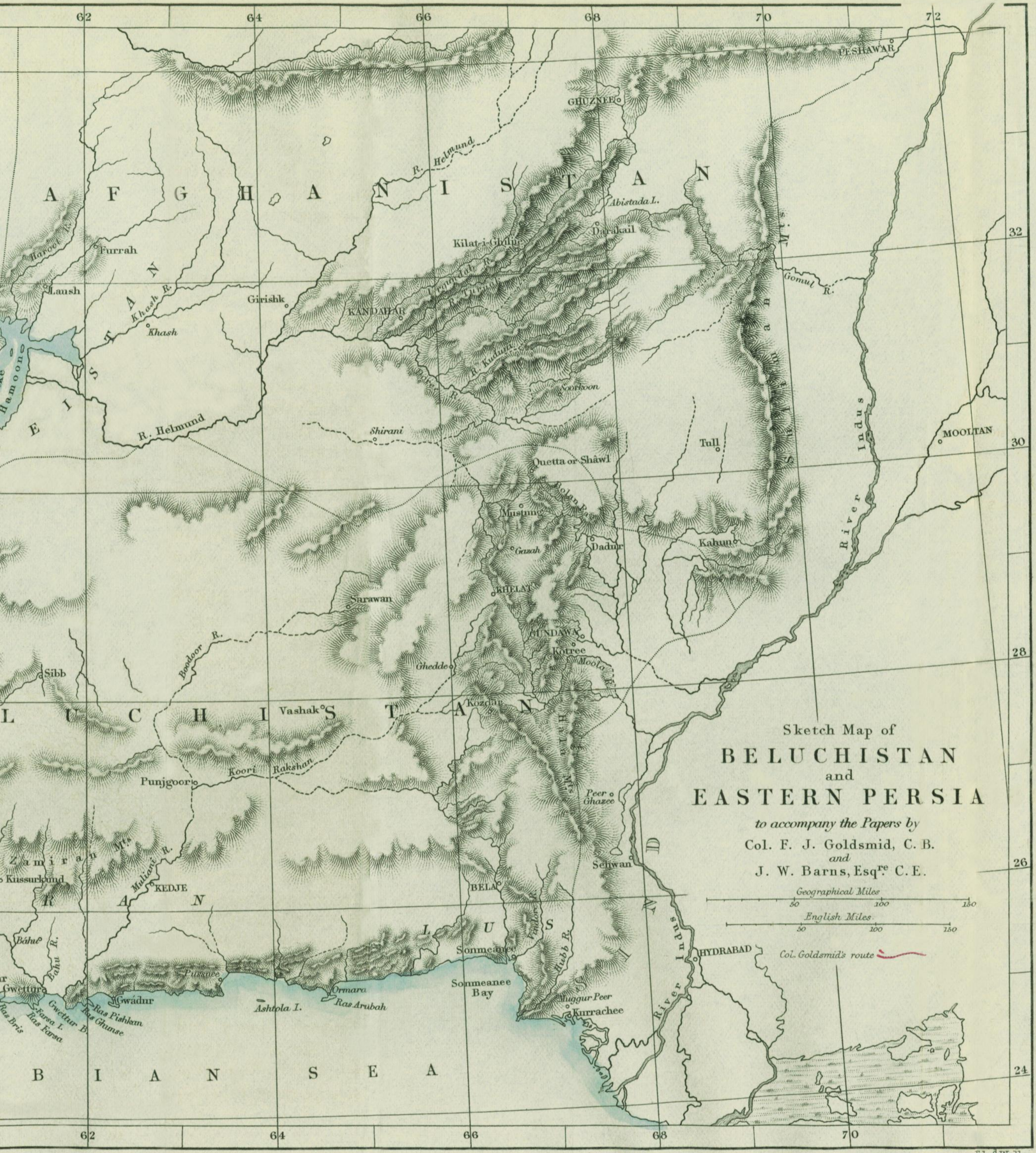

Sketch Map of
BELUCHISTAN
and
EASTERN PERSIA
to accompany the Papers by
Col. F. J. Goldsmid, C. B.
and
J. W. Barns, Esq.re C. E.

Edwd. Weller.

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